

**(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)**

**(19) World Intellectual Property Organization  
International Bureau**



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

**(43) International Publication Date**  
**21 June 2001 (21.06.2001)**

PCT

**(10) International Publication Number**  
**WO 01/43953 A1**

**(51) International Patent Classification<sup>7</sup>: B29D 11/00**

(72) **Inventor:** SHANNON, John, H.; 7122 Sandy Shore Drive, Hamlin, NY 14464 (US).

**(21) International Application Number:** PCT/US00/33585

(74) **Agents:** THOMAS, John, E. et al.; Bausch & Lomb Incorporated, One Bausch & Lomb Place, Rochester, NY 14604-2701 (US).

**(22) International Filing Date:**

11 December 2000 (11.12.2000)

(25) Filing Language: English

(26) **Publication Language:** English

**(30) Priority Data:**

09/464,603      15 December 1999 (15.12.1999)      US

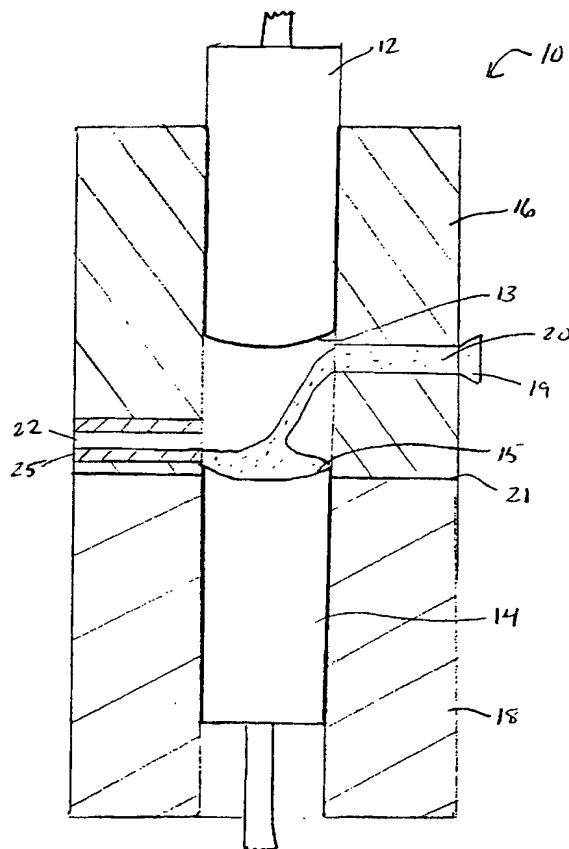
**(81) Designated States (national):** AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

**(71) Applicant: BAUSCH & LOMB INCORPORATED**  
[US/US]; One Bausch & Lomb Place, Rochester, NY  
14604-2701 (US).

**(84) Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,

*[Continued on next page]*

(54) Title: METHOD OF MOLDING LENSES



**(57) Abstract:** A method for directly molding lenses, especially contact lenses, provides a mechanism to remove excess lens material injected in the mold cavity and permits direct molding of a finished lens requiring no post-molding machining operations.

WO 01/43953 A1



IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *With international search report.*

## METHOD OF MOLDING LENSES

### Background of the Invention

This invention relates to a method for directly molding shaped articles such as ophthalmic lenses and/or biomedical devices. Representative articles are intraocular lenses and contact lenses. The method provides a mechanism to remove excess lens material injected in the mold cavity and permits direct molding of a finished lens requiring no post-molding machining operations.

A current method for molding contact lenses is cast molding, where a monomer mixture is charged between two mold sections, typically made of plastic, with one mold section having a molding surface shaped to form the anterior lens surface and the other mold section having a molding surface shaped to form the posterior lens surface; and then this mixture is cured between the mold sections. An example of such a method is described in US Patent No. 5,271,875 (Appleton). Typically, the plastic molds are first formed by injection molding, used to cast mold a single lens, and then discarded.

Prior to cast molding methods, various "direct molding" methods were known to mold a contact lens, i.e., the lens is cast in a permanent mold, made of a material such as glass or metal, rather than cast in "intermediate" plastic molds as in the aforementioned cast molding methods.

In both cast molding and direct molding processes, it is desired to mold a finished lens, i.e., a lens that does not require post-molding machining. It is also desired that the molding process is predictable and repeatable. This is complicated, however, since many lens material shrink upon curing.

Several processes of directly molding of lenses contemplate introducing into the mold cavity a precise, measured amount of lens-forming material. A problem with this approach is that it is difficult to control repeatedly the amount of lens-forming material introduced to the mold cavity, and if the amount of material is not precisely controlled, lenses having different dimensions may result. This is a particular problem with contact lenses since even slight variations in dimensions can affect optical properties or fitting characteristics of the lens.

Canadian application no. 2143901 describes a process for directly molding contact lenses where the apparatus includes an overflow reservoir to receive excess lens-forming material, the reservoir being located at the circumferential edge of the molding cavity. Since this reservoir is adjacent the molding cavity, it becomes necessary to ensure that the excess material in the reservoir is completely separated from the molded lens, otherwise the lens will have an uneven or rough edge. Ensuring such a "clean" separation between the molding cavity and the adjacent overflow reservoir becomes more complicated when using mold parts made of a non-deformable material, such as metal or glass.

This invention provides a method for directly molding lenses such as contact lenses that avoids the need to rely on introduction of a precise, measured amount of lens-forming material, and provides a mechanism to accommodate excess lens material introduced in the mold cavity while permitting molding of a finished lens.

#### Summary of the Invention

This invention provides a method of molding an ophthalmic lens in a mold comprising a first mold part and a second mold part. The first mold part has a molding surface shaped to provide a posterior lens surface and the second mold part has a second

molding surface shaped to provide an anterior lens surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another. The method comprises the steps of: (a) introducing lens-forming material between the first and second molding surfaces; (b) moving the mold parts towards each other so that the lens material is compressed in a space between the first and second molding surfaces; (c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess lens-forming material escapes into the outlet port; and (d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a lens between the molding surfaces of the repositioned mold parts. The invention also provides a method of molding a biomedical device in a mold and that comprises the aforementioned steps.

#### Brief Description of the Drawings

Figure 1 is a schematic cross-section view of an apparatus according to various embodiments, where the molding tools are in a position to receive lens-forming material.

Figure 2 is a schematic cross-section view of the apparatus of Figure 1, where the molding tools are positioned to compress the lens-forming material.

Figure 3 is a schematic cross-section view of the apparatus of Figure 1, where molding surfaces of the posterior and anterior molding tools are positioned in alignment with the outlet port.

Figure 4 is a schematic cross-section view of the apparatus of Figure 1, where the molding tools are positioned to mold a lens therebetween.

Figure 5 is a schematic cross-section view of the apparatus according to various alternate embodiments.

#### Detailed Description of Preferred Embodiments

Figure 1 illustrates an apparatus 10 according to various embodiments of this invention. The molding apparatus 10 includes a posterior molding tool 12 having a generally cylindrical shape and a molding surface 13 for forming the posterior surface of a lens. Anterior molding tool 14 has a generally cylindrical shape and a molding surface 15 for forming the anterior surface of a lens. The molding tools 12, 14 are received in bores of blocks 16, 18 separated by part line 21.

Lens-forming material 20 is introduced between molding surfaces 13, 15 via inlet port 19 which, in the illustrated embodiment, is formed in block 16. The lens-forming material is in a flowable state, and generally will be a liquid. For example, a nozzle of an injector may be received in inlet port 19, the nozzle injecting and dispensing the lens-forming material in the space between molding surfaces 13, 15. The apparatus also includes an outlet port 22 which, in the illustrated embodiment, is formed in block 18. Generally, an excess of the lens-forming material will be introduced between the molding tools at this stage.

During the introduction of the lens-forming material between the molding tools, tool 14 is positioned below outlet port 22, and tool 12 is positioned above inlet port 19.

The molding tool 12 is then moved towards molding tool 14 so that these tools assume the general configuration shown in Figure 2. In this configuration, both molding tools 12, 14 are positioned below outlet port 22. More specifically, molding tool 12 is moved towards molding tool 14 until a desired, predetermined position is obtained, with a compressive force being applied to the lens forming material in the mold cavity formed

between surfaces 13, 15. When the two molding tools are in this position, the spacing between the molding surfaces 13, 15 will generally be slightly larger than the ultimate mold cavity in the subsequent molding stage.

During this step in the process, the compression of the lens-forming mixture forces any gas in the cavity to escape. For example, the tolerance between the molding tools 12, 14 and the blocks 16, 18 is such that gas may escape but liquid lens-forming material will not be forced between the molding tools and the blocks.

Following this stage, both the anterior and posterior molding tools 12, 14 are repositioned to assume the general configuration shown in Figure 3. In this configuration, the cavity formed between molding surfaces 13, 15 is aligned with outlet port 22. Then, the molding tools are brought together until the molding surfaces 13, 15 have a predetermined, final spacing. During this stage, excess lens-forming material 20 is forced into the outlet port 22.

Then, both the molding tools 12, 14 are moved within the blocks 16, 18 to assume the general configuration shown in Figure 4. In this configuration, the molding cavity formed between surfaces 13, 15 is not aligned with either the inlet port or the outlet port. A compressive force is maintained while the lens-forming material is cured, to accommodate for shrinkage of the lens-forming material during curing. Heat can be applied by heating mechanism 25 to facilitate curing of the lens-forming material. If desired, the entire assembly can be placed under an inert environment, for example, in a nitrogen atmosphere, during curing.

Following curing of the lens-forming material, the posterior and anterior molding tools 12, 14 are separated and the lens is recovered. For example, the molding blocks may be separated along part line 21 to facilitate recovering the lens. Additionally, excess

lens material in the exit port 22 will generally be cured during curing of the lens-forming mixture in the cavity, and this excess material is removed. The cycle may then be repeated to form another lens.

Figure 5 illustrates an alternate embodiment where the apparatus is provided with an assembly 32 to assist in removal of excess cured lens material 31 from outlet port 22. In the illustrated configuration, assembly 32 includes a push-rod 33 that is received in a bore 34 in block 16, the bore 34 being aligned with outlet port 22. Thus, after the lens-forming material is cured to form contact lens 30, mold part 12 is retracted, and push-rod 33 is extended to push cured excess lens material 31 from port 22. Of course, prior to curing of the lens-forming material, push-rod 33 is retracted in bore 34.

Molding parts 12, 14 may be made of a rigid material such as metal or glass, with molding surfaces 13, 15 being an optically quality surface for forming the lens surfaces. Alternately, one or both of molding parts 12, 14 may be made of a plastic material. If the lens-forming material is photopolymerizable, radiation, such as UV radiation, can be directed to the mold cavity from radiation source 35, shown in Figure 5, in which case at least one of the posterior or anterior molding tools 12, 14 would be made of a radiation transmissive material. Alternately, polymerizing radiation may be directed to the cavity between surfaces 13, 15 by extending a fiber optic bundle through one of the mold parts 12, 14.

As previously mentioned, during curing of the lens-forming material, a compressive force is maintained to accommodate shrinkage of the lens material. The molding surfaces 13, 15 may ultimately come into contact with one another, at the edges of the molding surfaces, or these edges of the molding surfaces may remain displaced from one another. In the former case, the edge of the lens is formed between the



contacting edges of the molding surfaces; in the latter case, the edge of the lens is at least partially shaped by the bore walls of the block 16. When the molding surfaces come into contact with each other to form the lens edge, the mold parts may be made of materials with different hardnesses, so that the harder molding surface deforms the softer molding surface to facilitate the formation of a finished edge. In such a case, the softer mold part is preferably made of a plastic that is disposed after each molding cycle.

While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. For example, the molding surfaces of the molding tools may be shaped to form additional device features, such as haptics in the case of intraocular lenses. Therefore, the invention is not limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope and spirit of the appended claims.

I claim:

1. A method of molding an ophthalmic lens in a mold comprising a first mold part and a second mold part, the first mold part having a first molding surface shaped to provide a posterior lens surface and the second mold part having a second molding surface shaped to provide an anterior lens surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another, said method comprising:

(a) introducing lens-forming material between the first and second molding surfaces;

(b) moving the mold parts towards each other so that the lens material is compressed in a space between the first and second molding surfaces;

(c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess lens-forming material is received in the outlet port; and

(d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a lens between the molding surfaces of the repositioned mold parts.

2. The method of claim 1, wherein in step (a), the lens material is injected between the first and second molding surfaces.

3. The method of claim 1, wherein in step (b), the first mold part is moved towards the second mold part.

4. The method of claim 1, wherein step (c) includes positioning the first and second molding surfaces to a predetermined spacing while the space between these surfaces is aligned with the outlet port.

5. The method of claim 1, wherein step (d) includes heating the lens-forming material to cure the lens-forming material.

6. The method of claim 1, wherein step (d) includes exposing the lens-forming material to radiation to cure the lens-forming material.

7. The method of claim 1, further comprising separating the mold parts and recovering the lens.

8. The method of claim 1, wherein the lens is a contact lens.

9. A method of molding a biomedical device in a mold comprising a first mold part and a second mold part, the first mold part having a first molding surface and the second mold part having a second molding surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another, said method comprising:

(a) introducing a device-forming material between the first and second molding surfaces;

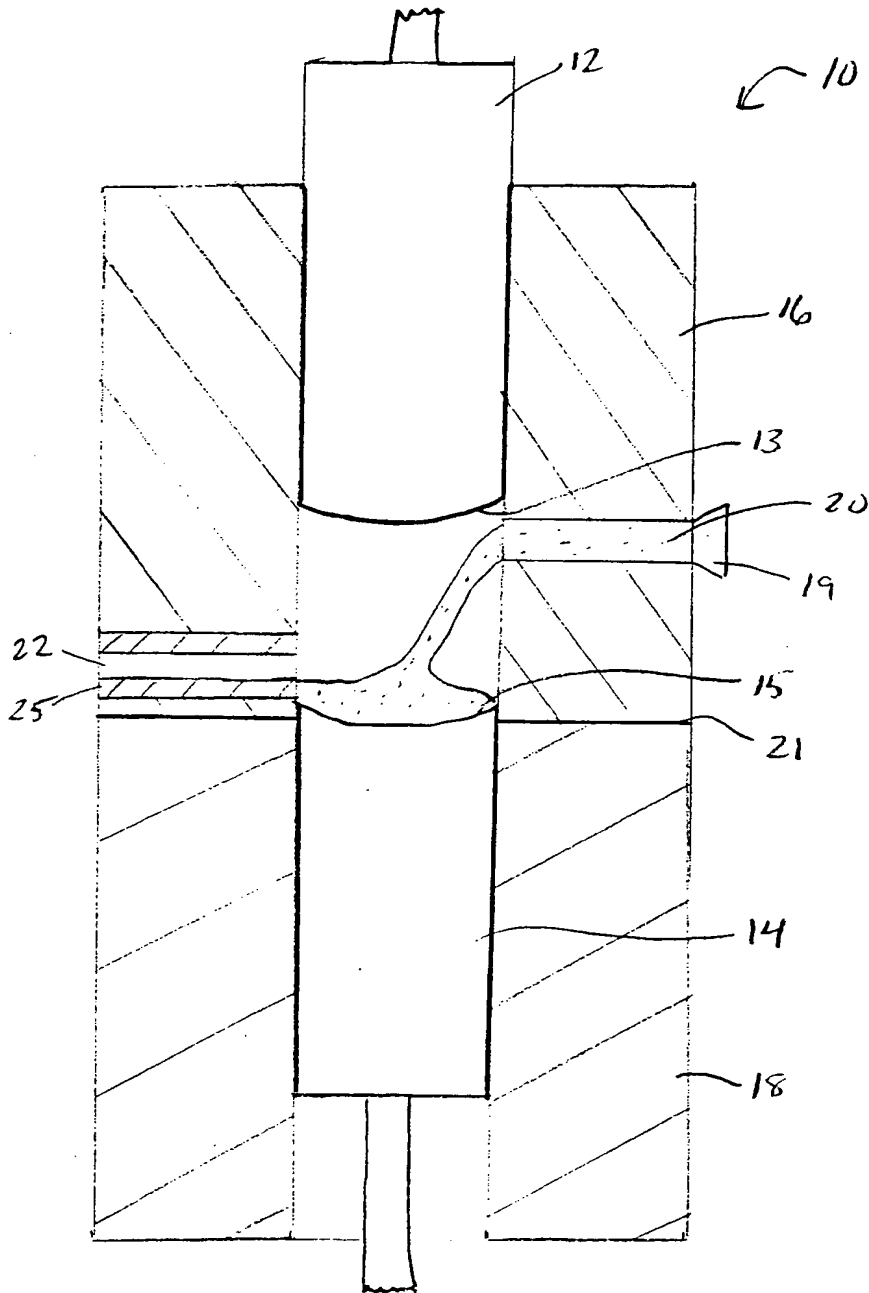
(b) moving the mold parts towards each other so that said material is compressed in a space between the first and second molding surfaces;

(c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess device-forming material is received in the outlet port; and

(d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a medical device between the molding surfaces of the repositioned mold parts.

10. The method of claim 9, wherein the device is a contact lens, and the first molding surface is shaped to provide a posterior lens surface and the second molding surface is shaped to provide an anterior lens surface.

Fig. 1



F.g. 2

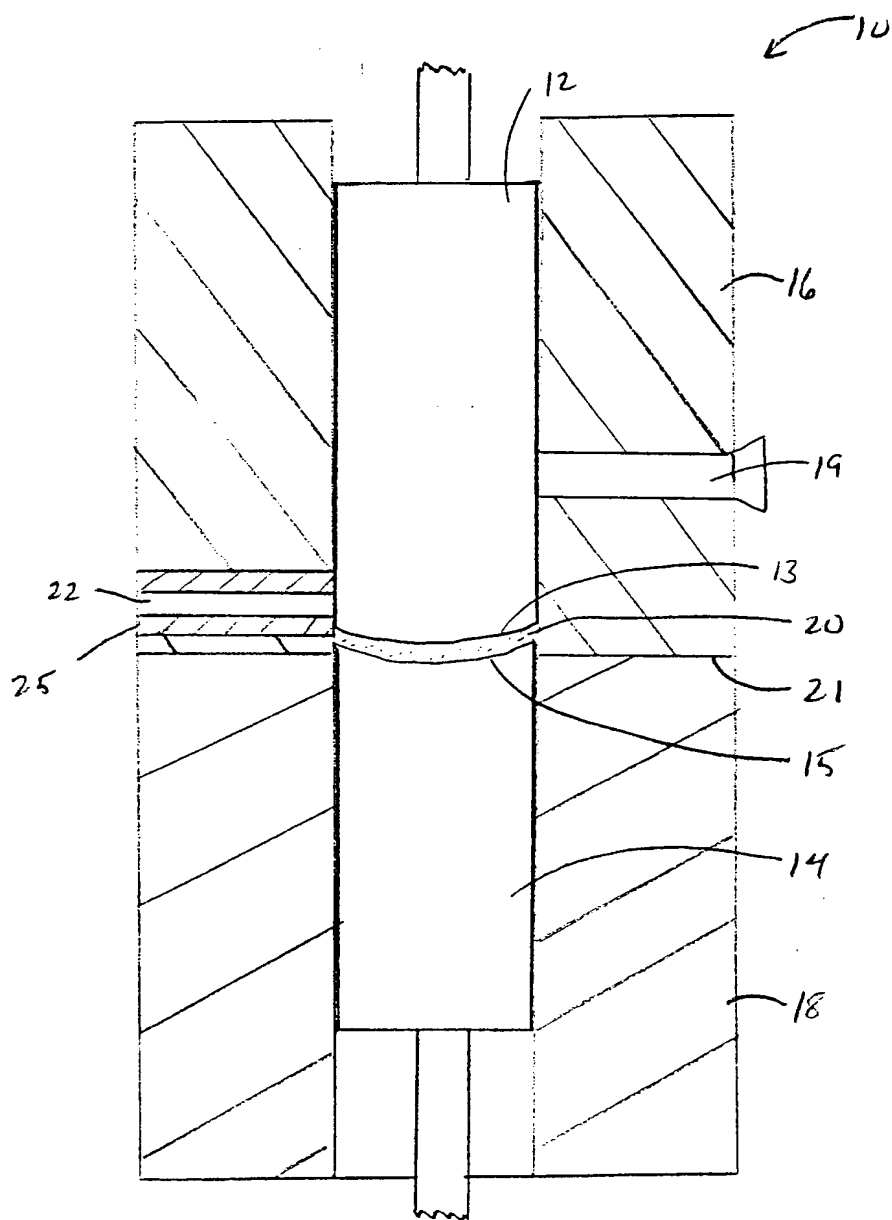
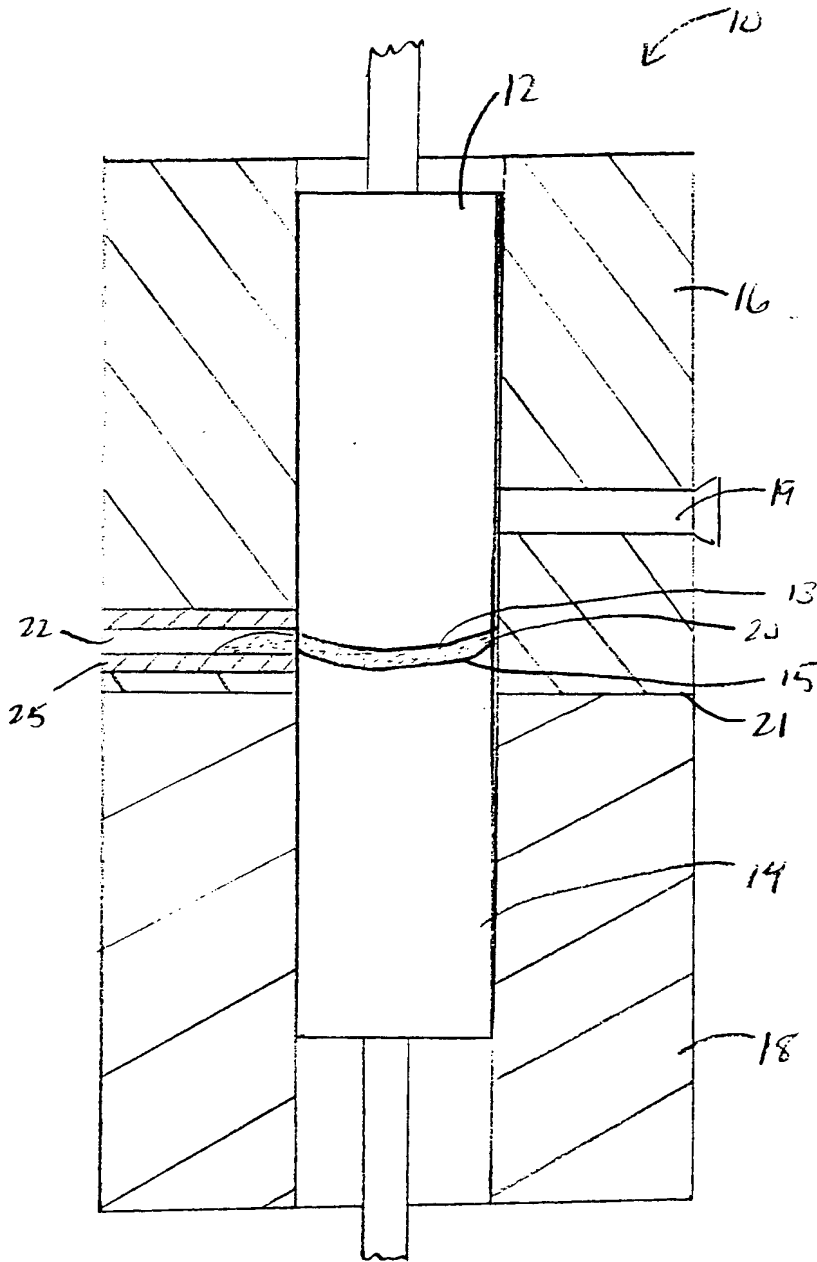
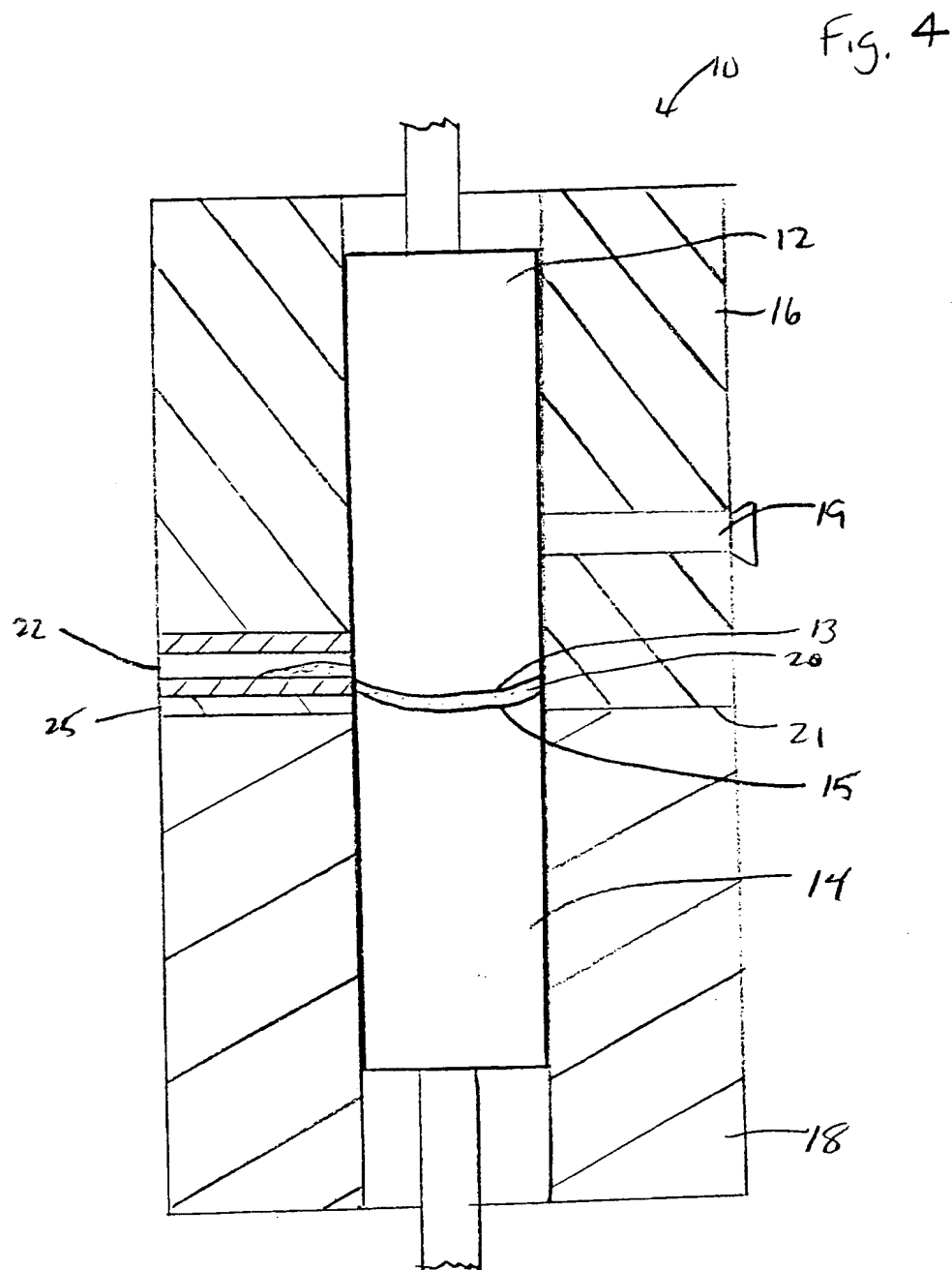


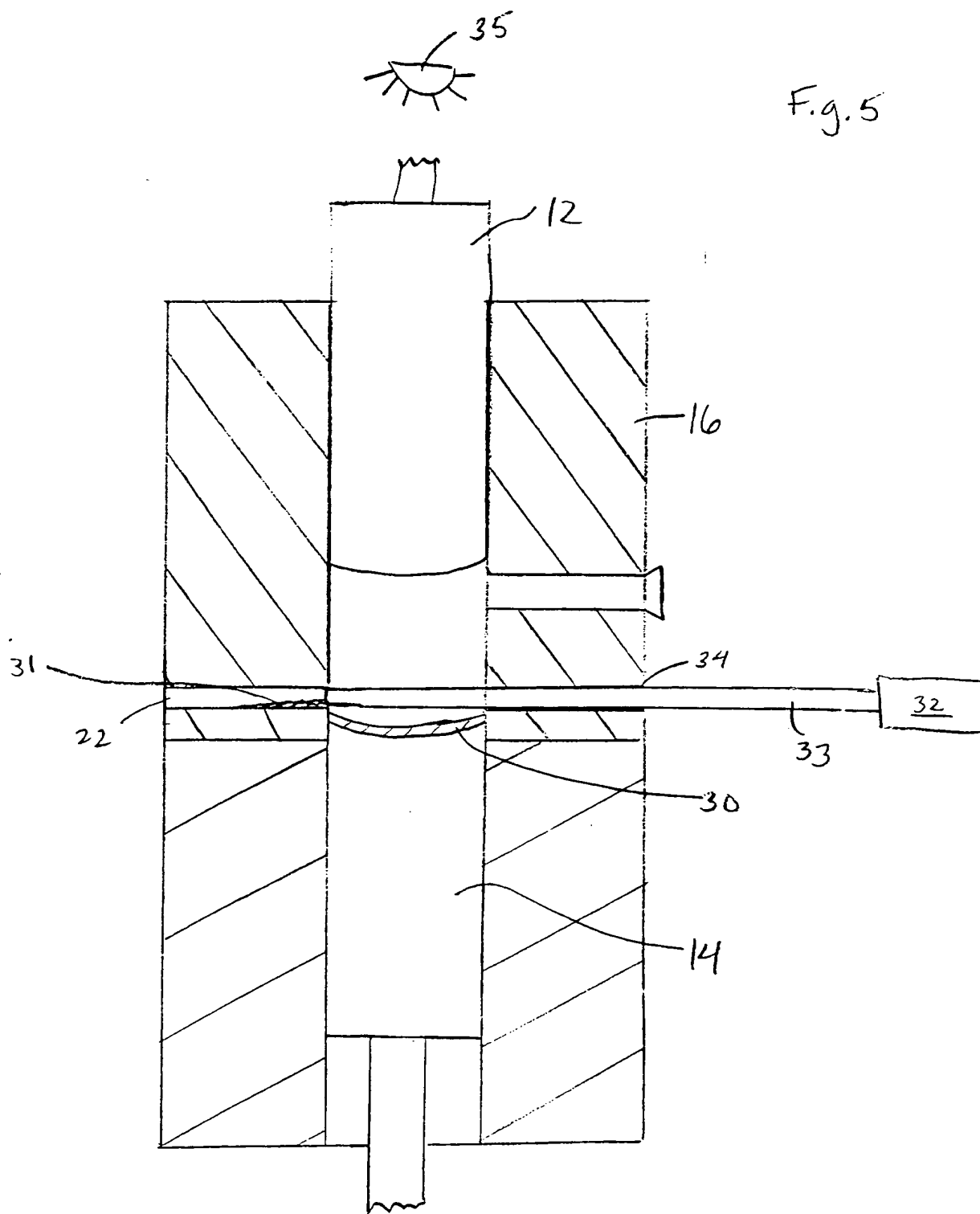
Fig 3







F.g. 5



## INTERNATIONAL SEARCH REPORT

Internat Application No

PCT/US 00/33585

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 B29D11/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 005 234 A (ORIANI, CAPPELLI) 24 October 1961 (1961-10-24) column 3, line 50 - column 4, line 13; figures 6-8	1, 3, 4, 7, 8
Y	FR 2 530 181 A (ESSILOR INT) 20 January 1984 (1984-01-20) page 12, line 2 - line 29; figures 2A-2C	1-4, 7
Y	US 4 284 591 A (NEEFE CHARLES W) 18 August 1981 (1981-08-18) column 2, line 15 - line 31	1-4, 7
A	GB 2 027 386 A (OMNITECH INC) 20 February 1980 (1980-02-20)	
A	WO 94 23929 A (SOLA GROUP LTD) 27 October 1994 (1994-10-27)	

☐ Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*G\* document member of the same patent family

Date of the actual completion of the international search

7 March 2001

Date of mailing of the international search report

16/03/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Roberts, P

# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 00/33585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3005234 A	24-10-1961	NONE	
FR 2530181 A	20-01-1984	JP 1667597 C JP 3024328 B JP 59026221 A US 4569807 A	29-05-1992 03-04-1991 10-02-1984 11-02-1986
US 4284591 A	18-08-1981	NONE	
GB 2027386 A	20-02-1980	AU 524955 B AU 4902379 A BE 878148 A CA 1124469 A DE 2932499 A FR 2432929 A JP 1405129 C JP 55027300 A JP 62012019 B NL 7905618 A, B, US 4364878 A	14-10-1982 14-02-1980 03-12-1979 01-06-1982 28-02-1980 07-03-1980 09-10-1987 27-02-1980 16-03-1987 12-02-1980 21-12-1982
WO 9423929 A	27-10-1994	US 5405557 A AU 678006 B AU 6559494 A AU 678578 B AU 6706694 A DE 69411721 D DE 69411721 T DE 69411728 D DE 69411728 T EP 0696955 A EP 0695231 A WO 9423928 A US 5523030 A	11-04-1995 15-05-1997 08-11-1994 05-06-1997 08-11-1994 20-08-1998 15-04-1999 20-08-1998 18-03-1999 21-02-1996 07-02-1996 27-10-1994 04-06-1996

